

What is claimed is:

1. Glass collectively comprising at least 70 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, and containing not more than 30 percent by weight collectively As₂O₃, B₂O₃, GeO₂, P₂O₅, SiO₂, TeO₂, and V₂O₅, based on the total weight of the glass.
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2. The glass according to claim 1, wherein if Al₂O₃, at least one of Y₂O₃ or REO, and at least one of ZrO₂ or HfO₂ are present, the glass comprises either not greater
10 than 4 or at least 6 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.
3. The glass according to claim 1, wherein if Al₂O₃, at least one of Y₂O₃ or REO, and at least one of ZrO₂ or HfO₂ are present, the glass comprises at least 6 percent
15 by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.
4. The glass according to claim 3 collectively comprising at least 75 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.
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5. The glass according to claim 3 collectively comprising at least 80 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.
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6. The glass according to claim 3 collectively comprising at least 85 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.
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7. The glass according to claim 3 collectively comprising at least 90 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

8. The glass according to claim 3 collectively comprising at least 99 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

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9. The glass according to claim 3 collectively comprising 100 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass.

10 10. The glass according to claim 3 collectively comprising at least 70 percent by weight of Al₂O₃, at least one of ZrO₂ or HfO₂, and at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

11. The glass according to claim 10, wherein the at least one of ZrO₂ or HfO₂ is present in an amount of at least 5 percent by weight, based on the total weight of the glass.

15 12. The glass according to claim 10, wherein the at least one of ZrO₂ or HfO₂ is present in an amount of at least 10 percent by weight, based on the total weight of the glass.

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13. The glass according to claim 3 collectively comprising at least 70 percent by weight of Al₂O₃, Y₂O₃, and at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

25 14. The glass according to claim 3, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount of at least 10 percent by weight, based on the total weight of the glass.

15. The glass according to claim 3 collectively comprising at least 70 percent 30 by weight of Y₂O₃, at least one of ZrO₂ or HfO₂, and at least one of Nb₂O₅ or Ta₂O₅.

16. The glass according to claim 15, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount greater than 5 percent by weight, based on the total weight of the glass.

5 17. The glass according to claim 15, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount of at least 10 percent by weight, based on the total weight of the glass.

10 18. The glass according to claim 3 comprising greater than 5 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

19. The glass according to claim 3 comprising at least 10 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

15 20. The glass according to claim 3 comprising at least 15 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

21. The glass according to claim 3 comprising at least 20 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

20 22. The glass according to claim 3 comprising at least 25 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

23. The glass according to claim 3 comprising the at least one of Nb₂O₅ or 25 Ta₂O₅, in a range from 10 to 40 percent by weight, based on the total weight of the glass.

24. The glass according to claim 3 collectively comprising at least 70 percent by weight of Al₂O₃, Y₂O₃, at least one of ZrO₂ or HfO₂, and at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.

25. The glass according to claim 24, wherein the at least one of ZrO₂ or HfO₂ is present in an amount of at least 5 percent by weight, based on the total weight of the glass.

26. The glass according to claim 24, wherein the at least one of ZrO₂ or HfO₂ is
5 present in an amount of at least 10 percent by weight, based on the total weight of the glass.

27. Ceramic comprising the glass according to claim 3.

10 28. A method for making the glass according to claim 3, the method comprising:

melting sources of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂ to provide a melt; and cooling the melt to provide the glass.

15 29. A method for making ceramic comprising glass according to claim 3, the method comprising:

melting sources of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂ to provide a melt; and cooling the melt to provide the ceramic.

30. A method for making an article comprising glass according to claim 3, the method comprising:

providing glass powder comprising glass, the glass collectively comprising
25 at least 70 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, and containing not more than 30 percent by weight collectively As₂O₃, B₂O₃, GeO₂, P₂O₅, SiO₂, TeO₂, and V₂O₅, wherein if Al₂O₃, at least one of Y₂O₃ or REO, and at least one of ZrO₂ or HfO₂ are present, the glass comprises at least 6 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the
30 total weight of the glass , the glass having a T_g; and

heating the glass powder above the T_g such that the glass beads coalesce to form a shape and provide the article.

31. An optical waveguide comprising:

5 a substrate; and

a glass according to claim 3 on a surface of the substrate.

32. The optical waveguide according to claim 31, wherein the glass is doped with a rare earth dopant.

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33. The optical waveguide according to claim 32 wherein the rare earth dopant is selected from the group consisting of cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, or their other compounds and mixtures thereof.

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34. An optical waveguide comprising a glass fiber having a core material and a cladding surrounding the core material, wherein the core material comprises a glass according to claim 3.

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35. The optical waveguide according to claim 34, wherein the glass is doped with a rare earth dopant.

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36. The optical waveguide according to claim 35, wherein the rare earth dopant is selected from the group consisting of cerium, praseodymium, neodymium, promethium, samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium, ytterbium, or their other compounds, and mixtures thereof.

37. An optical amplifier comprising:
an optical pump source which provides optical pump light; and
an optical waveguide coupled to receive the optical pump light from
the optical pump source, wherein the optical waveguide comprises a glass
according to claim 3.
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38. The optical amplifier according to claim 37, wherein the glass is doped with
a rare earth dopant.
- 10 39. The optical amplifier according to claim 38, wherein the rare earth dopant
is selected from the group consisting of cerium, praseodymium, neodymium, promethium,
samarium, europium, gadolinium, terbium, dysprosium, holmium, erbium, thulium,
ytterbium, or their other compounds, and mixtures thereof.
- 15 40. A method for amplifying optical signals, the method comprising:
inputting the optical signals to an optical waveguide comprising a glass
according to claim 3; and
applying pump light to the optical waveguide to cause the waveguide to
provide optical gain to the optical input signals.
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41. The method according to claim 40, wherein the glass is doped with a rare
earth dopant.
- 25 42. Ceramic comprising at least 75 percent by volume glass, the glass
collectively comprising at least 70 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅
and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, and
containing not more than 30 percent by weight collectively As₂O₃, B₂O₃, GeO₂, P₂O₅,
SiO₂, TeO₂, and V₂O₅, based on the total weight of the glass.
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43. The ceramic according to claim 42, wherein if Al_2O_3 , at least one of Y_2O_3 or REO, and at least one of ZrO_2 or HfO_2 are present, the glass comprises either not greater than 4 or at least 6 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

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44. The ceramic according to claim 42, wherein if Al_2O_3 , at least one of Y_2O_3 or REO, and at least one of ZrO_2 or HfO_2 are present, the glass comprises at least 6 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass.

10 45. Glass-ceramic collectively comprising at least 70 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) Y_2O_3 , or (c) at least one of ZrO_2 or HfO_2 , and containing not more than 30 percent by weight collectively As_2O_3 , B_2O_3 , GeO_2 , P_2O_5 , SiO_2 , TeO_2 , and V_2O_5 , based on the total weight of the glass-ceramic.

15 46. The glass-ceramic according to claim 45, wherein if Al_2O_3 , at least one of Y_2O_3 or REO; and at least one of ZrO_2 or HfO_2 are present, the glass-ceramic comprises either not greater than 4 or at least 6 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass-ceramic.

20 47. The glass-ceramic according to claim 45, wherein if Al_2O_3 , at least one of Y_2O_3 or REO, and at least one of ZrO_2 or HfO_2 are present, the glass-ceramic comprises at least 6 percent by weight of the at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass-ceramic.

25 48. The glass-ceramic according to claim 47 collectively comprising at least 75 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) Y_2O_3 , or (c) at least one of ZrO_2 or HfO_2 , based on the total weight of the glass-ceramic.

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49. The glass-ceramic according to claim 47 collectively comprising at least 80 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

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50. The glass-ceramic according to claim 47 collectively comprising at least 85 percent by weight (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

10 51. The glass-ceramic according to claim 47 collectively comprising at least 90 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

15 52. The glass-ceramic according to claim 47 collectively comprising at least 95 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

20 53. The glass-ceramic according to claim 47 collectively comprising at least 99 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

25 54. The glass-ceramic according to claim 47 collectively comprising 100 percent by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃, or (c) at least one of ZrO₂ or HfO₂, based on the total weight of the glass-ceramic.

55. The glass-ceramic according to claim 47 collectively comprising at least 70 percent by weight of Al₂O₃, at least one of ZrO₂ or HfO₂, and at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass-ceramic.

5 56. The glass-ceramic according to claim 55, wherein the at least one of ZrO₂ or HfO₂ is present in an amount of at least 5 percent by weight, based on the total weight of the glass-ceramic.

10 57. The glass-ceramic according to claim 55, wherein the at least one of ZrO₂ or HfO₂ is present in an amount of at least 10 percent by weight, based on the total weight of the glass-ceramic.

15 58. The glass-ceramic according to claim 47 collectively comprising at least 70 percent by weight of Al₂O₃, Y₂O₃, and at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass-ceramic.

59. The glass-ceramic according to claim 58, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount of at least 10 percent by weight, based on the total weight of the glass-ceramic.

20 60. The glass-ceramic according to claim 47 collectively comprising at least 70 percent by weight of Y₂O₃, at least one of ZrO₂ or HfO₂, and at least one of Nb₂O₅ or Ta₂O₅.

25 61. The glass-ceramic according to claim 50, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount greater than 5 percent by weight, based on the total weight of the glass-ceramic.

30 62. The glass-ceramic according to claim 60, wherein the at least one of Nb₂O₅ or Ta₂O₅ is present in an amount of at least 10 percent by weight, based on the total weight of the glass-ceramic.

63. The glass-ceramic according to claim 47 collectively comprising at least 70 percent by weight of Al_2O_3 , Y_2O_3 , at least one of ZrO_2 or HfO_2 , and at least one of Nb_2O_5 or Ta_2O_5 , based on the total weight of the glass-ceramic.

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64. The glass-ceramic according to claim 63, wherein the at least one of ZrO_2 or HfO_2 is present in an amount of at least 5 percent by weight, based on the total weight of the glass-ceramic.

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65. The glass-ceramic according to claim 63, wherein the at least one of ZrO_2 or HfO_2 is present in an amount of at least 10 percent by weight, based on the total weight of the glass-ceramic.

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66. A method for making glass-ceramic according to claim 47, the method comprising:

heat-treating glass to convert at least a portion of the glass to crystalline ceramic and provide the glass-ceramic, the glass collectively comprising at least 70 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) Y_2O_3 , or (c) at least one of ZrO_2 or HfO_2 , and containing not more than 30 percent by weight collectively As_2O_3 , B_2O_3 , GeO_2 , P_2O_5 , SiO_2 , TeO_2 , and V_2O_5 .

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67. A method for making glass-ceramic according to claim 47, the method comprising:

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heat-treating ceramic comprising glass to convert at least a portion of the glass to crystalline ceramic to provide the glass-ceramic, the glass collectively comprising at least 70 percent by weight of (i) at least one of Nb_2O_5 or Ta_2O_5 and (ii) at least two of (a) Al_2O_3 , (b) Y_2O_3 , or (c) at least one of ZrO_2 or HfO_2 , and containing not more than 30 percent by weight collectively As_2O_3 , B_2O_3 , GeO_2 , P_2O_5 , SiO_2 , TeO_2 , and V_2O_5 .

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68. A method for making a glass-ceramic article, the method comprising:
providing glass powder, the glass collectively comprising at least 70 percent
by weight of (i) at least one of Nb₂O₅ or Ta₂O₅ and (ii) at least two of (a) Al₂O₃, (b) Y₂O₃,
or (c) at least one of ZrO₂ or HfO₂, and containing not more than 30 percent by weight
5 collectively As₂O₃, B₂O₃, GeO₂, P₂O₅, SiO₂, TeO₂, and V₂O₅, based on the total weight of
the glass, the glass having a T_g;

heating the glass powder above the T_g such that the glass powder coalesces
to form a shape and provide a glass article; and

10 heat-treating the glass article to convert at least a portion of the glass to
crystalline ceramic to provide the glass-ceramic article.

69. The method according to claim 68, wherein if Al₂O₃, at least one of Y₂O₃
or REO, and at least one of ZrO₂ or HfO₂ are present, the glass comprises either not greater
than 4 or at least 6 percent by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the
15 total weight of the glass.

70. The method according to claim 68, wherein if Al₂O₃, at least one of Y₂O₃
or REO, and at least one of ZrO₂ or HfO₂ are present, the glass comprises at least 6 percent
by weight of the at least one of Nb₂O₅ or Ta₂O₅, based on the total weight of the glass.